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The *Æcidium* as a Device to
Restore Vigor to the Fungus.



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The question how the two common wheat rusts (*Puccinia graminis* and *P. rubigo-vera*) maintain themselves in the northern United States and Canada is yet a debatable problem, although it has received much attention during the last dozen years. It was in the winter of 1888-9 that Bolley made the discovery that in Indiana the early rust (*P. rubigo-vera*) is able to maintain itself throughout the winter in the tissues of the living wheat plant, forming uredospores whenever the weather is favorable for growth, and in this manner starting the rust again in the spring. The observation has been repeated by Eriksson in Sweden. Early rust, therefore, appears to depend chiefly, and perhaps entirely, upon a semi-perennial mycelium and the production uredospores, for its distribution in space and time. To be sure, it forms an abundance of teleutospores, capable of germination, but these must come to naught, for an æcidium, which might be ascribed to this species, has never been detected in America, although one occurs occasionally in Europe. The supposed discovery by Plowright of a direct infection of the wheat plant from germinating teleutospores has not been confirmed, and he, himself, has publicly stated that he was in error.

So far as we know, then, the early rust of wheat in the colder parts of North America produces but one efficient sort of spore, the uredospore, which all mycologists consider a strictly asexual spore, having no rejuvenating power above ordinary vegetative reproduction. Carleton considers, and it seems to me with justice, that the early rust does much less injury to the wheat crop, as a rule, than stem rust, although it comes earlier and is usually more abundant. Before turning to the stem rust of wheat let me call attention to the rust of Kentucky blue grass (*Poa pratensis*). This rust (*Puccinia Poarum*) is found throughout North America, from the Atlantic to the Pacific, wherever the host occurs. It attracts little attention, however, even from collectors, and rarely appears in local lists of fungi. In gathering information some time ago I wrote to a number of botanists, and ascertained

that in many localities, even where the rust had not been suspected, almost any tuft of blue grass that had grown tall and thick, would show upon examination to have practically every leaf affected. In Europe this rust possesses three forms of spores: uredospores for summer distribution, teleutospores for passing the winter, and æcidiospores for spring distribution, the last forming on coltsfoot (*Tussilago Farfara*), which is there a common weed. In America, however, only uredospores are known, and the winter is passed in the form of persistent mycelium within the living grass leaves, a method exactly corresponding to that of the early rust of wheat. Coltsfoot has become established to some extent along the Hudson river, and in various localities in the New England States, but no æcidium has yet been found on it, although I am not aware that special search has been made.

Turning now to the stem rust, or black rust, of wheat (*Puccinia graminis*) a different course of development prevails. There is no evidence that the mycelium ever persists in the living wheat plant throughout the winter; and the teleutospores, which germinate readily in spring, can not start the season's infection except indirectly through the intervention of barberry bushes. That wheat rust can grow on the barberry has been abundantly demonstrated, and not a few times in the writer's own laboratory. That it must grow on the barberry before the wheat fields in any particular region can become infected is quite a different proposition, and wholly untenable. It has been suggested that possibly in the parts of America where wheat is extensively grown and barberry bushes are few or absent some common weed might harbor the æcidium instead of the barberry. The very common æcidium on evening primrose has been mentioned as very likely a stage of the wheat rust. But this æcidium belongs to one of the many rusts on *Carex*, as conclusively shown by cultures of the present season. Moreover, the accumulated knowledge of the last few years makes it beyond belief that any plant beside the barberry, or a very near relative like the mahonia, can harbor wheat rust, thus enabling it to complete its cycle of development. If barberry and mahonia bushes were entirely ex-

terminated over the whole of the American continent, I believe that stem rust of wheat (not the early rust, of course) would soon wholly disappear. There is one possibility that it might not, however; in favored localities of the south it might continue to produce uredospores the year round, which each succeeding summer might be blown from field to field northward, and the whole country be successively infected. But the fact is that several species of barberry are native to North America, being found throughout the Rocky Mountains from British Columbia southward, and in the Alleghanies from Virginia southward. Besides, a number of old world species have been rather extensively planted for ornament or hedges throughout the United States and Canada. That these cultivated and native species of barberry bear *æcidia* is amply attested by the herbaria of the country, as well as by common observation. There are, therefore, plenty of centers where spring infection of grain fields may begin, and having once started extensive distribution rapidly takes place. It seems to me highly probable that an annual northward distribution of the rust by uredospores actually occurs, as deduced by Bolley from his studies of the problem. Whether wheat rust, through its uredospores, can or can not infect rye, oats, barley or the cultivated and wild grasses does not affect the problem under discussion. To keep the question in its simplest form, we may say that it cannot, which is probably close to the facts.

I have tried to present an outline of the behavior of three common rusts to serve as a background for the particular thing that I wish to emphasize in this paper, and which I will now bring forward. I can not get to the heart of the matter quicker than to describe an observation made in 1892. At one edge of a field of wheat on the Experiment Station farm at Lafayette, Ind., were many large barberry bushes, forming a thicket some twenty-five by fifty feet. The season was favorable to the production of rust, and the barberry bushes were well covered with *æcidia*. By the first week in July the wheat field was also well rusted, but not uniformly. Before the wheat was ripe the stems were well blackened with teleutospores on the plants growing close to the barberries, and as one

passed out into the wheat field, away from the barberries, black rust showed less and the red of the uredospores more, until fifty to seventy-five feet away only the red rust was noticeable. So marked was this that one noticed at a glance the gradation from the ordinary rusted condition of the field in general, becoming darker, up to the much blackened condition close by the barberry bushes. The interpretation of this phenomenon appears to be that the spores from the barberry *æcidia* infected the wheat plants abundantly near by, and to a less and less degree farther away, few spores reaching beyond seventy-five feet. Mycelium developed from the *æcidiospores* formed uredospores for a much shorter period than that from the uredospores, and began earlier to form teleutospores and produced them in greater abundance. In other words, the *æcidiospores* give rise to a much more vigorous state of the fungus than the uredospores do. This is in accord with the observation of farmers that the red rust does little harm to the wheat crop compared with the black rust. If barberry bushes were abundant, so that wheat fields could be largely infected directly from *æcidia*, there is no question that rust would do far more serious injury to the wheat crop than it now does. On the other hand, the usual absence of barberry bushes greatly lessens the harmfulness of the stem rust; and in the early rust of wheat and the special rust of Kentucky blue grass the total absence in America of a host for the *æcidia* reduces their harmfulness still more.

Such facts as these, placed with many other small matters which can not well be introduced here, lead me to conclude that the *æcidium* with its accompanying spermogonia represents the original sexual stage of the fungus, and that it still retains much of its reinvigorating power. This inference is upheld to some extent, or at least is not opposed, by recent cytological studies upon the behavior of nuclei in fungi of this and related orders. At any rate we have here, I believe, a working hypothesis of some value. The extended production of uredospores in any grass or sedge rust, possibly any sort of rust, may be taken to indicate, according to this theory, that the *æcidium* is rare or absent in that vicinity. As a practical deduction, we may conclude that to prevent the production of *æcidiospores* by removal of the host, or otherwise, will much reduce the injury which the rust is capable of producing.

